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Close Combat Armaments Center

Understanding Extractor Lift in the M16 Family of Weapons

Frank Dindl
U.S Army TACOM-ARDEC
AMSTA-AR-CCL-A; Bldg 7
Picatinny Arsenal, NJ 07806
(973) 724-6761
<fdindl@pica.army.mil>

Gary Houtsma
U.S. Army TACOM-ARDEC
AMSTA-AR-CCL-A; Bldg 7
Picatinny Arsenal, NJ 07806
(973) 724-2549
<ghoutsma@pica.army.mil>

Shing Chor Chung
U.S. Army TACOM-ARDEC
AMSTA-AR-CCL-A; Bldg 7
Picatinny Arsenal, NJ 07806
(973) 724-6458
<scchung@pica.army.mil>

Lily Ko
U.S. Army TACOM-ARDEC
AMSTA-AR-CCL-A; Bldg 65
Picatinny Arsenal, NJ 07806
(973) 724-6761
<lilyko@pica.army.mil>

Objective:

Present conclusive evidence to support the theory that extractor lift consistently occurs during rearward translation of the bolt, and not during bolt rotation during unlocking.

Background:

Several theories for explaining extractor lift and failure to extract in M16 family weapons have been proposed. The most popular has been that extractor lift is caused by “spin out”, where the centrifugal forces acting on the extractor as the bolt rotates during unlocking causes the forward tip of the extractor to lift away from the rim of the cartridge case.

The “spin out” theory was subjected to a simple experiment to show that this is not the cause of extractor lift. An M16 bolt with a standard extractor was mounted in a high speed drill press and spun in excess of 8,000 rpm. A strobe light was used to verify the spin rate and to show the position of the extractor. No extractor lift was observed.

This experiment was repeated after modifying the extractor by adding a lump of weld material to the end of the extractor. No extractor lift was observed even under these exaggerated conditions.

Picture of Bolt with Standard Extractor:

Picture of Bolt with Modified Extractor:

An alternative theory was that extractor lift occurs during the initial high rearward acceleration of the bolt at the beginning of case extraction, after bolt rotation was completed. High speed photography of a cutaway weapon showed that extractor lift is a common occurrence in the M4 carbine. An additional theory was proposed suggesting that residual chamber pressure holds the fired cartridge case against the bolt face while the extractor lifts out of position, and keeps the case against the bolt face long enough for the end of the extractor to return to the case rim.

Problem:

Failures to extract are extremely rare in the M4 carbine. One failure to extract in thousands of rounds fired, under adverse conditions, makes measuring the failure to extract related weapon stoppages statistically difficult to accomplish, and nearly impossible to duplicate from one test to another.

Solution:

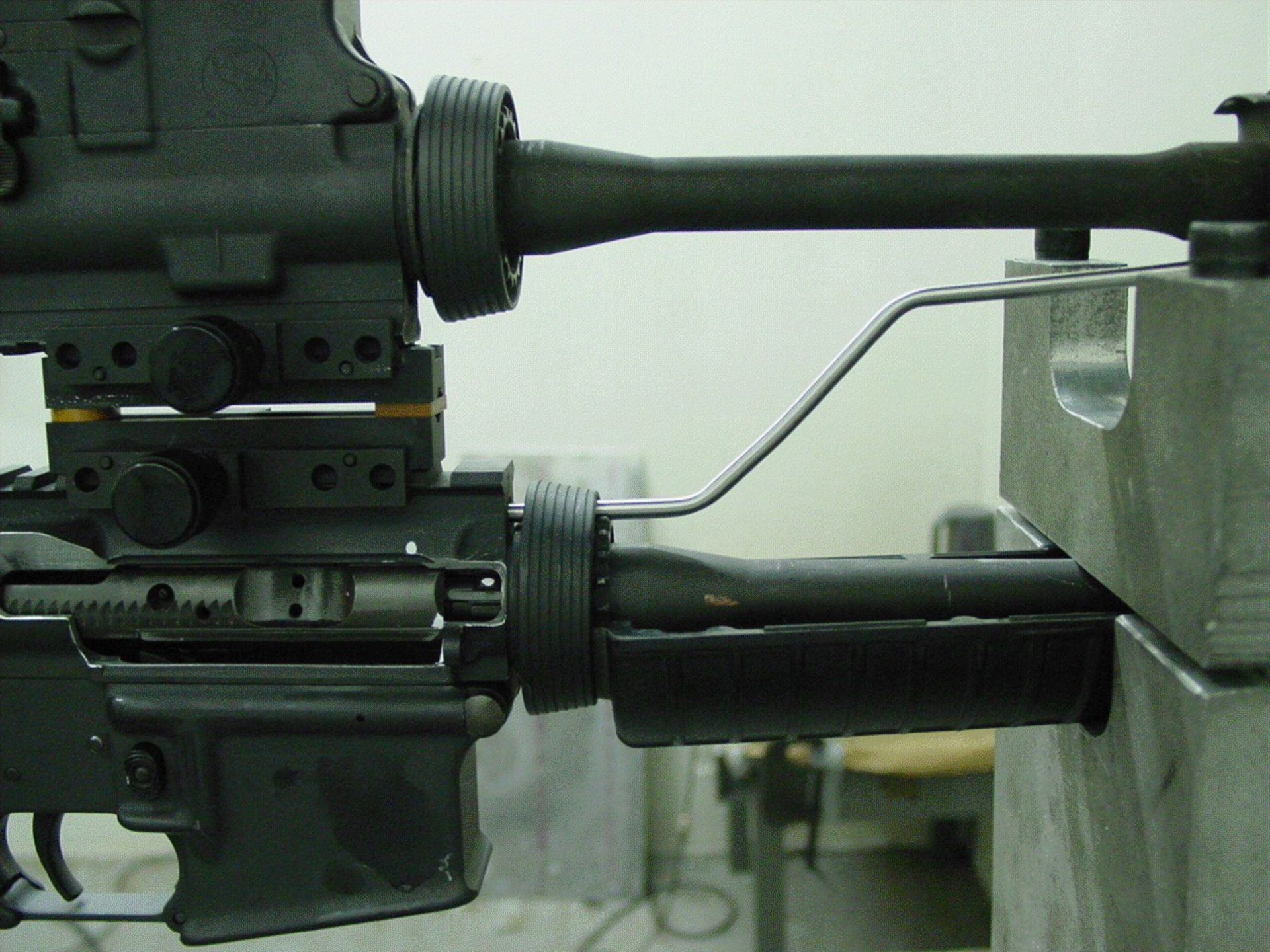
Altering the weapon dynamics in a laboratory environment allows for assessing the influence of various factors on failures to extract.

A simple high fidelity weapon gymnasticator was built to explore these theories. In the following picture, the gas tube from the top M4 was attached to the receiver of the bottom M4. The weapon gymnasticator allowed for examining weapon dynamics with residual chamber pressure removed.

Several experiments were conducted to explore how residual chamber pressure may compensate for extractor lift. The following high speed video clips show the highlights of these experiments. One representative video clip for each experimental configuration is shown. Each experiment was repeated several times with the same results.

Dual M4 High Fidelity Gymnasticator

Ball round fired in top weapon to power bolt carrier in bottom weapon

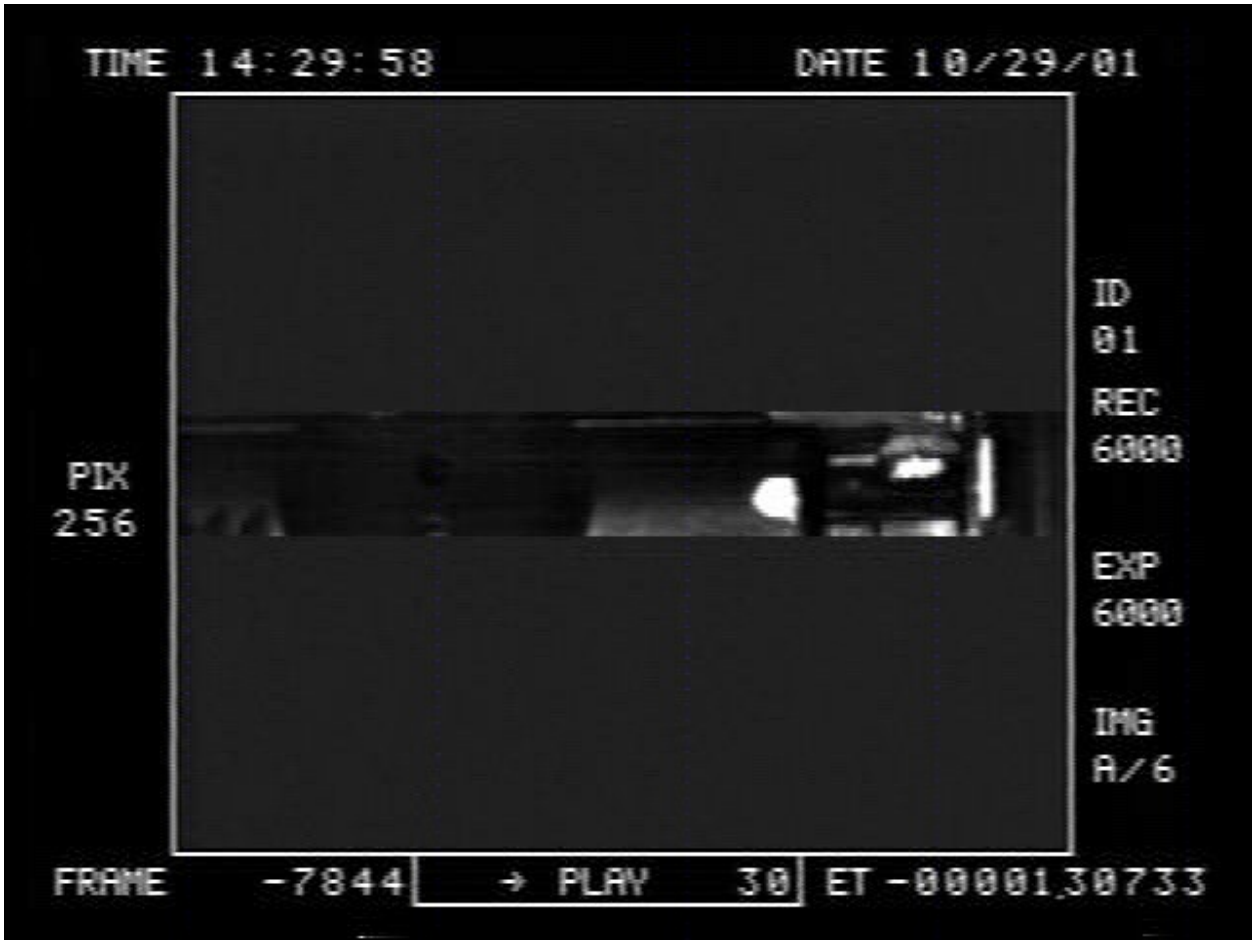


Shot 1:

A ball round was chambered and fired in the lower M4.

A ball round was then fired in the upper M4 to power the lower M4 bolt carrier.

The fired case in lower M4 chamber failed to extract

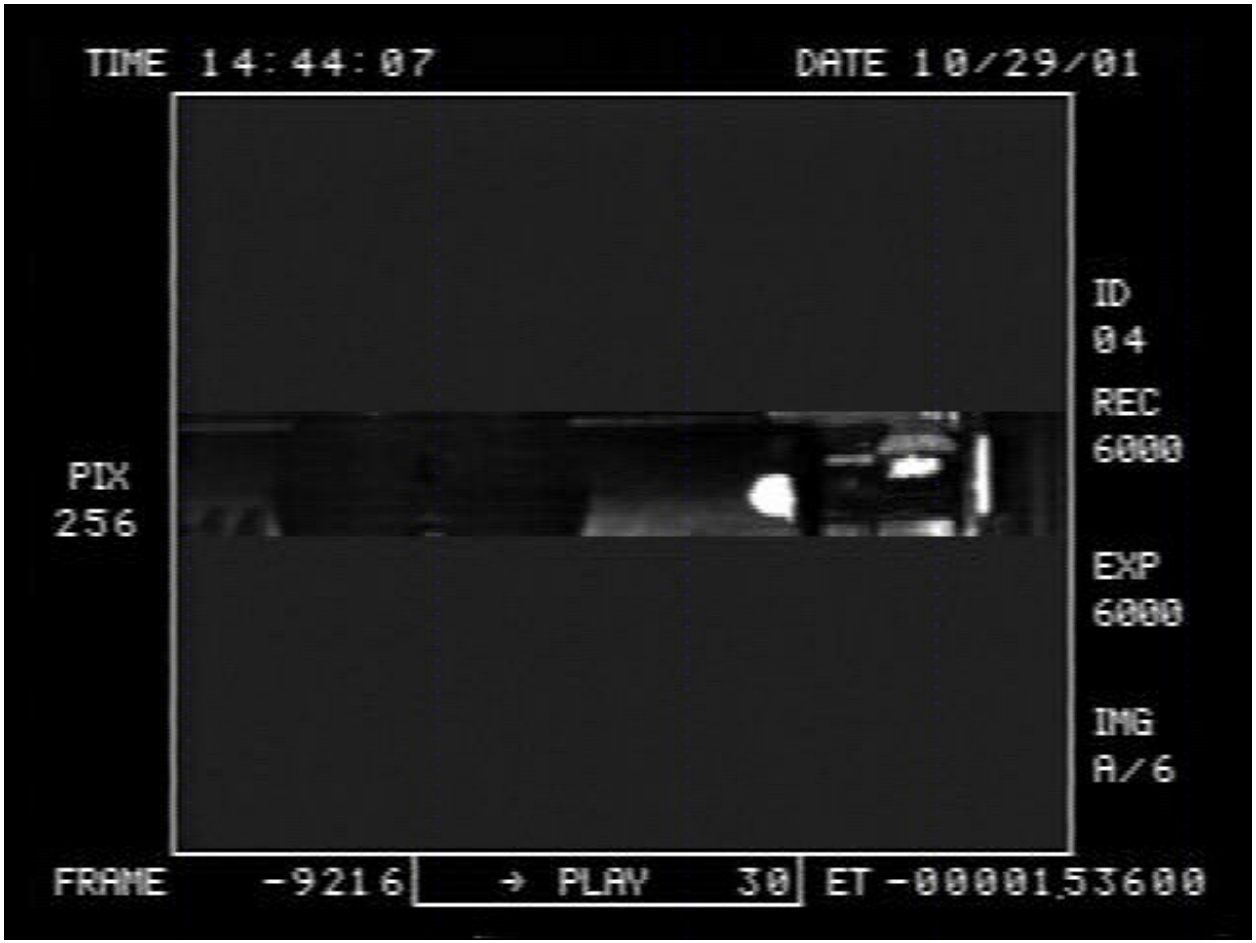


Shot 4:

An unfired, lubed and primed cartridge case was chambered in the lower M4.

A ball round was fired in the upper M4 to power the bolt carrier in the lower M4.

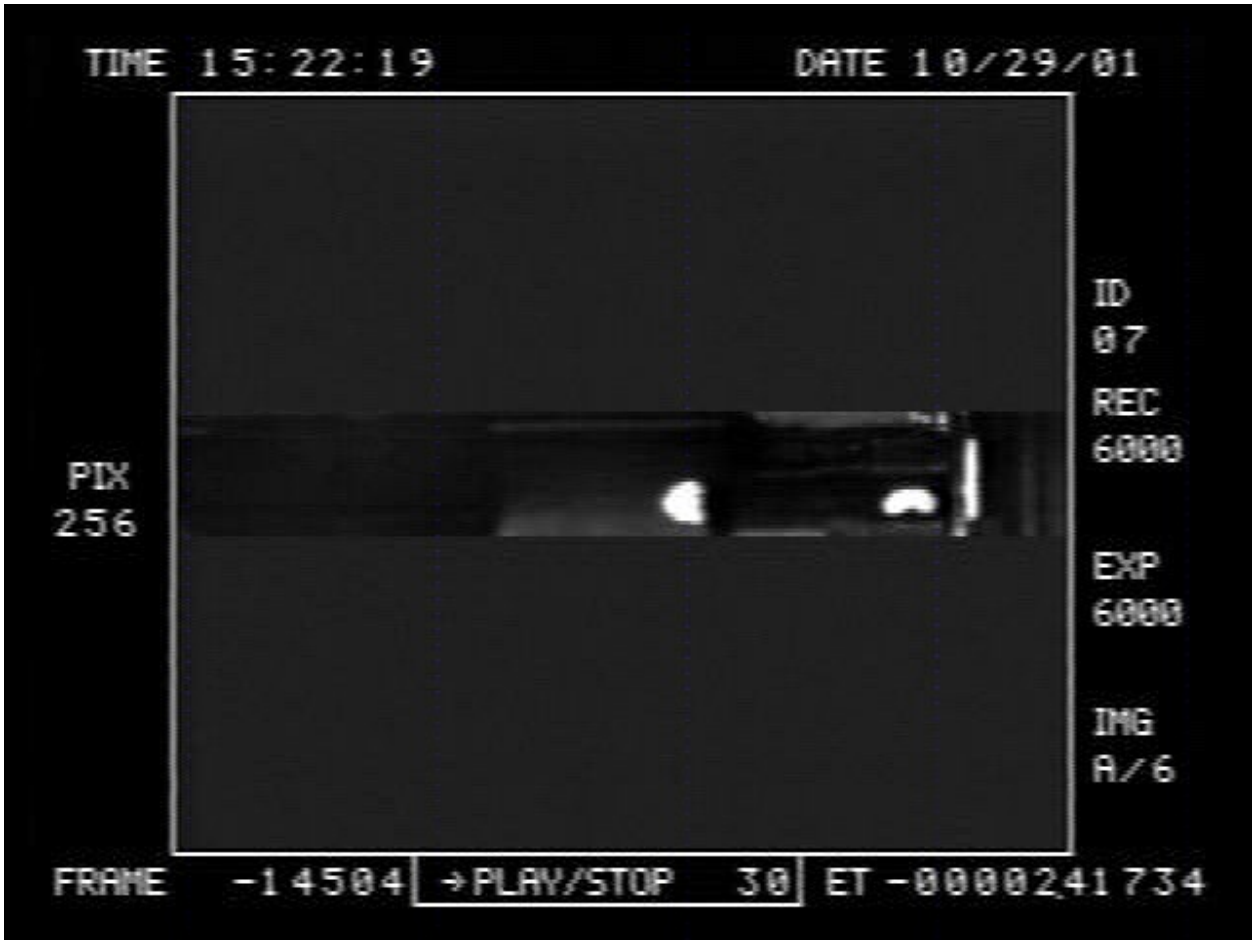
The unfired case in the lower M4 fails to extract



Shot 7:

The ejector in the lower M4 was removed and the previous experiment was repeated.

The unfired, lubed and primed case in the lower M4 extracted.



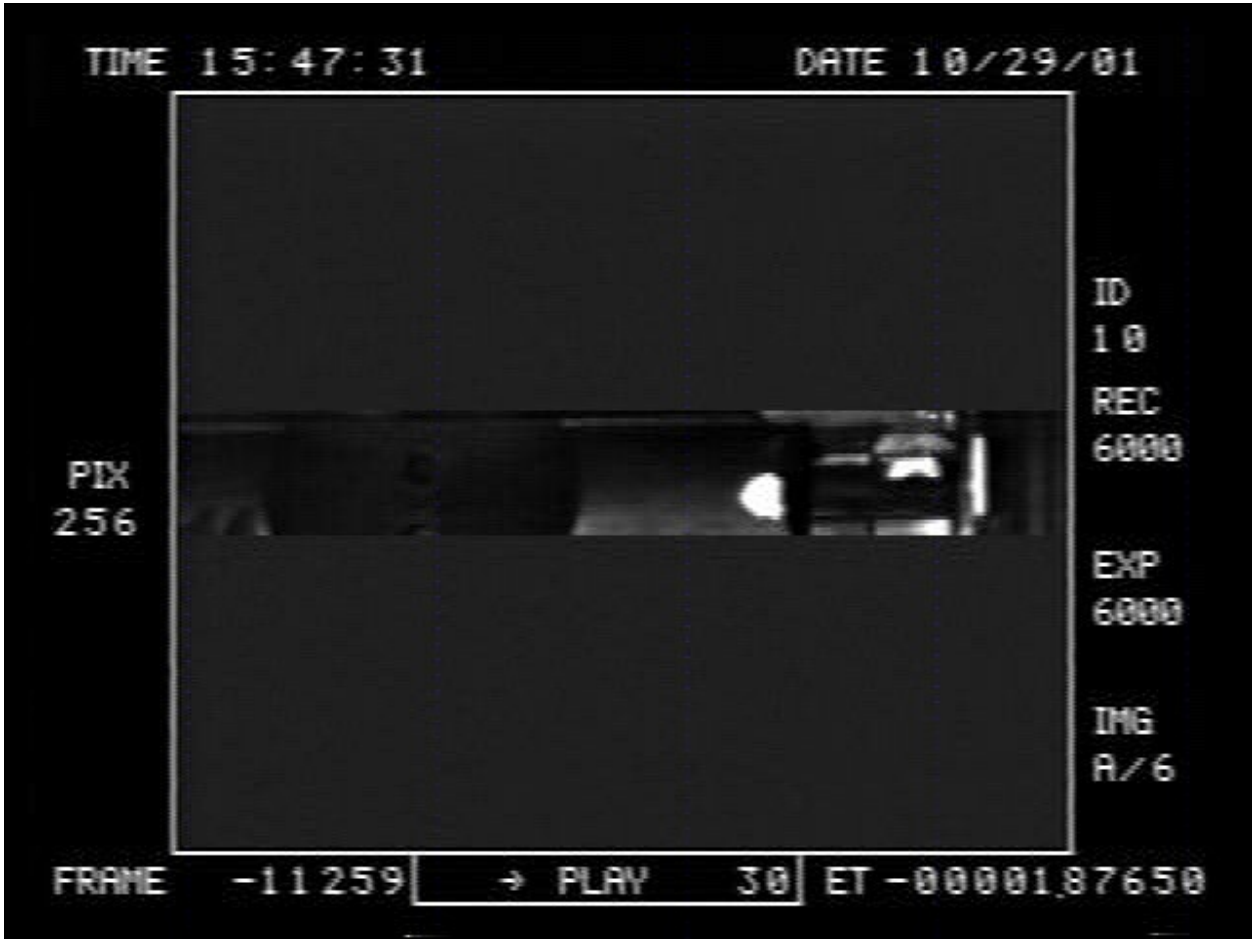
The extractor imparts an initial rearward velocity to the cartridge case. For shot #7, the case coasts along behind the bolt when the ejector is not present, allowing the extractor to lift and then return to the case rim.

Shot 10:

No ejector in the lower M4 (same as for the preceding experiment).

Case dinged to create drag on case in the chamber during extraction.

Dinged case fails to extract.



Conclusions:

Extractor lift occurs during the initial rearward translation of the bolt after bolt rotation stops.

Case extraction and ejection successfully occur as long as the case is held against the bolt face by the residual chamber pressure while the extractor lifts and returns to position.

Other Comments:

The reliability of the M4 and M16 family of weapons surpasses the performance specifications for these weapons. Improving our understanding of weapon dynamics will allow for the development of future improvements to further enhance reliability.

Extreme care must be exercised to ensure that any weapon changes are thoroughly tested to avoid introducing a new failure mechanism or otherwise reducing the reliability of the weapon!